

USE OF LONG-TERM MONITORING DATA TO EVALUATE POTENTIAL IMPACTS OF ASIAN CARP ON NATIVE FILTER-FEEDING FISHES IN THE UPPER MISSISSIPPI RIVER SYSTEM

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Bighead Carp (*Hypophthalmichthys nobilis*) and Silver Carp (*H. molitrix*) were accidentally introduced into the Mississippi River system in the 1980s, presumably from the aquaculture industry. Both *Hypophthalmichthys* spp. are filter feeders and it has been suggested that they could potentially impact native filter-feeders because of similar dietary preferences. We used 10 years of daytime electrofishing data collected by the Long Term Resource Monitoring Program (LTRMP) in three Asian Carp colonized reaches of the Upper Mississippi River System (UMRS; Pool 26, unimpounded UMR, and LaGrange reach of the Illinois River) and one un-colonized reach (e.g., control site) of the UMRS (Pool 13) to test for potential impacts from *Hypophthalmichthys* on annual Gizzard Shad (*Dorosoma cepedianum*) and Bigmouth Buffalo (*Ictiobus cyprinellus*) biomass estimates. Although we found negative, but non-significant correlations for stock and sub-stock *D. cepedianum* in the colonized reaches (except Pool 26 for stock), before-and-after impact (BACI) analyses revealed no significant interactions among the impacted and control sites and biomass estimates before and after Asian Carp establishment. The only negative, yet non-significant correlation for *I. cyprinellus* biomass was for sub-stock in the LaGrange Pool, and BACI revealed no significant interaction between this reach, the control reach, and biomass estimates before and after Asian Carp establishment in the LaGrange Pool. Although we found no significant correlations or interactions in our analyses, we can not confidently conclude that there are no negative impacts from Asian Carp on native filter-feeding fishes because the UMRS is a highly productive system and resources may not yet be limited. Conversely, impacts may not yet be identifiable because of the short time-series since Asian Carp establishment in the UMRS. Because we identified negative correlations in biomass through time for *D. cepedianum* and *I. cyprinellus*, we recommend continued monitoring of these species.

Wing dike morphology and habitat use by bighead and silver carps.

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The channelized portion of the Missouri River is characterized by a large, swift channel bounded by wing dikes. Telemetry data indicates that low velocity, deep water preferred by the invasive bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*H. molitrix*) in the Missouri River is primarily associated with the plunge pools behind the wing dikes. We used GIS and aerial photography to characterize 15 parameters of wing dikes in a 209 km reach of the Missouri River, and coupled those data with telemetry data from that reach, to determine the characteristics of wing dikes that determine use by bighead and silver carps.

Morphometrics for the determination of sex and hybridization in *Hypophthalmichthys* species.

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Bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*H. molitrix*) apparently hybridize readily in the wild in the United States. Five percent of *Hypophthalmichthys* captured in the Missouri River in the summer of 2005 were nominal hybrids. Hybrids can be difficult to identify because they can closely resemble either of the parent species, and because the hybrids are fertile and backcrosses may exist. Incorrect identification of hybrids can compromise research findings. Various authors have had success in identification of the sex of *Hypophthalmichthys* using ridges or tubercles on the pectoral fins, but other researchers have found that those secondary sexual characteristics are not always adequate, especially during periods when the fish are not sexually active. We measured several morphometric parameters on a large number of fish to determine which parameters would be most useful in determining hybridization and the sex of *Hypophthalmichthys*. Genetic analysis was used to verify hybridization on a subset of samples.

Draft Management and Control Plan for Asian Carps in the United States

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The Aquatic Nuisance Species Task Force (Task Force) requested the U.S. Fish and Wildlife Service (USFWS) develop a national management and control plan for bighead, black, grass, and silver carps. The Task Force and USFWS organized an Asian Carp Working Group (Working Group) consisting of representatives from federal, state, and Canadian natural resources management agencies, Native American tribes, industry professionals, universities, and non-governmental organizations. These partners have worked collaboratively to develop a comprehensive plan that includes a variety of control strategies and specific actions to be taken by federal, state, and local agencies, as well as the private sector to prevent introductions, contain and control wild populations, and to mitigate negative effects on native systems. The draft plan is currently under review by the Task Force. Once approved by the Task Force, the Working Group will lead efforts to solicit public comments and refine the draft management plan as necessary. A final revised management and control plan will be submitted to the Task Force for implementation approval. Ultimately this plan will provide for coordination of national management and control efforts for Asian carps and will be useful in efforts to secure additional funding required to effectively manage and control Asian carps in the United States.

The U.S. Fish and Wildlife Service Triploid Grass Carp Inspection and Certification Program

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The U.S. Fish and Wildlife Service (USFWS) offers a Triploid Grass Carp Inspection and Certification Program (Program) to assist in the protection of aquatic habitats. Many states rely on the Program to prevent accidental or deliberate unauthorized stockings of diploid (fertile) grass carp as triploids (functionally sterile). The Program is intended to provide assurance to these agencies, and others concerned about protecting aquatic resources, that shipments of grass carp alleged to be all triploid, do not, within the confidence limits of the inspection program, contain diploids. A set of standards have been developed to provide quality assurance which the USFWS uses to provide consistency and fairness in dealing with different circumstances encountered in the implementation of a national Program. The critical elements of the Program are described in four categories: (1) Standards for USFWS Inspectors; (2) Standards for Grass Carp Producers; (3) Checklist for Inspectors and Producers; and (4) Standards for Collection and Fees. The standards are available on the Internet at:
<http://warmsprings.fws.gov/FishHealth/index.html>.

Implementing the *Draft Management and Control Plan for Asian Carps in the United States*, U.S. Fish & Wildlife Service, Region 3 Fisheries Program's 2006 Asian Carp Projects

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While not formally approved by the Aquatic Nuisance Species Task Force, the U.S. Fish and Wildlife Service (USFWS), Region 3 Fisheries Program is taking the first steps towards implementing a few of the 131 recommendations developed by the Asian Carp Working Group (Working Group). The Carterville Fishery Resources Office chairs the Working Group and has led the development of the draft national management and control plan for bighead, black, grass, and silver carps. The Carterville, Columbia, and LaCrosse Fishery Resources Offices, along with the Large Rivers Coordination Office and the LaCrosse Fish Health Center, are actively involved in a number of projects to improve efforts to prevent introductions and to manage and control populations of Asian carps in the Mississippi and Missouri Rivers. Projects that are underway or planned to begin during 2006 include:

- Investigating alternatives to black carp for snail control in aquaculture ponds
- Development of an alternative fish diet made from Asian carps for piscivorous zoo and aquaria animals
- Development of a GIS-based tool to evaluate potential spawning and recruitment habitats for Asian carps in the Mississippi River
- Testing the effectiveness of a mid-water trawl designed specifically to capture Asian carps
- Summary of state regulations pertaining to the import and possession of live Asian carp
- Development of an acoustic telemetry network in the upper Illinois River to track Asian carps
- Early detection monitoring for Asian carps in the upper Illinois River
- Outreach to help prevent introductions of Asian carps in new waters
- Wild Fish Health Survey activities to detect Spring Viremia of Carp Virus (SVCV)

Zooplankton diet of bighead and silver carp in the lower Missouri River and one of its tributaries.

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The Asiatic bighead and silver carps invaded the Missouri River system in the 1990's and are now the most numerous large fishes in the lower portion of the river. Both species are considered filter feeders, subsisting primarily on zooplankton and phytoplankton. Seeking to understand the impact of these introduced carp on Missouri River fishery resources as it relates to their diet, we collected foreguts of both carp species along with samples of phytoplankton and zooplankton (64 and 100 micron mesh) during two sampling events per season from areas on the Missouri and the Lamine rivers in central Missouri. Both species consumed large fractions of fine particulate organic matter (FPOM) which appeared to be plant and detrital fragments and invertebrate fecal matter - bighead carp (60-97%), silver carp (86-96%). Bighead carp consumed a larger proportion of zooplankton than did silver carp, particularly in the spring and early summer; silver carp ate a larger proportion of phytoplankton and smaller zooplankton overall dominated by rotifers. Zooplankton diets reflected ratios in the environment.

Invasive Animals CRC - Freshwater Products and Strategies Program

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The Invasive Animals Cooperative Research Centre (IA CRC) represents the first truly national effort addressing the control and eradication of vertebrate pest animals in Australia. With over forty national and international partners, it includes four research programs:

- Terrestrial Products and Strategies
- Freshwater Products and Strategies
- Uptake
- Detection and Prevention

The Freshwater Products and Strategies Program brings together the combined resources of state, national and international Natural Resource Management agencies, Universities and research agencies. Whilst the primary objective is to develop an integrated pest fish management plan for the Murray-Darling Basin, the products and strategies being developed will have much wider application for fisheries management. These strategies include chemical controls, trapping and physical barriers, long term biological controls, early detection and prevention processes, population modeling and ecological/biological vulnerability analyses of species such as carp and tilapia. The cooperative platform of the CRC promotes coordinating and integrating of these project themes between research partners to achieve successful applied pest fish management outcomes.

Habitat Availability Study of Asian Carp on the Lower Missouri River and Tributaries

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The silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*H. nobilis*) are two of the invasive Asian carp species that are being studied to determine habitat availability in the Lower Missouri River (LMOR). Location and depth data from telemetered Asian carp combined with hydroacoustic bathymetry and velocity measurements of an 8-kilometer segment of the LMOR were used to determine habitat use. Results indicate that adult silver and bighead carp primarily used areas with depths greater than two meters. Mean water velocity of sites where carp were located sites was 0.041 meters/second. These areas were characterized by the Froude number, calculated from velocity and depth data, at < 0.09 . Habitat availability was determined by computing areas meeting the Froude number criterion at 1-99% flow exceedance river discharges in a 2-dimensional hydraulic model of the representative reach with tributary junction. Modeling indicates that carp habitats persist over a wide range of discharges. Availability is minimally affected by low flows and increases substantially for overbank flows.

Hybridization between silver and bighead carp in the Mississippi and Illinois Rivers.

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Bighead and silver carp can be differentiated from one another by a number of distinct morphological characteristics. Fish sharing morphological characteristics of both bighead and silver carp have been captured in Swan Lake, a contiguous backwater lake located on river mile 5-12 along the Illinois River in Calhoun County, Illinois. A small biopsy of muscle, liver and eye were collected from these morphological intergrades and compared to field-identified bigheads and silvers at several enzymatic loci via starch gel allozyme electrophoresis. In addition to the morphological variants showing a high degree of genetic hybridization, some of the fish identified in the field as true bigheads and silvers also displayed hybrid genotypes, with few fish exhibiting pure bighead or silver genotypes. These data suggest a potential for a hybrid swarm between these two species. Replacement of pure bighead and silver carp by some degree of bighead X silver hybrid is a plausible concern. The impact of this hybrid condition, both ecologically and taxonomically, warrants further attention. Additional collections and analyses of fish from alternate sites along the Mississippi and Illinois Rivers is being conducted. The use of microsatellite and mtDNA markers will be implemented in future investigations.

SILVER CARP (*Hypophthalmichthys molitrix*) AND BIGHEAD CARP (*H. nobilis*) IN THE MISSISSIPPI RIVER BASIN: OCCURRENCE DATA AND DISPERSAL PATTERNS

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Silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*H. nobilis*) are Asian fishes that have become established in the Mississippi River Basin of North America. Because of the potential threat these invaders pose to native aquatic ecosystems, there is interest in determining their dispersal dynamics. We recently used a simple diffusion model as a heuristic tool to gain insight into the dispersion of another aquatic invader, the Rio Grande cichlid (*Herichthys cyanoguttatus*), in southeastern Louisiana. This approach correctly predicted the unexpected occurrence of this freshwater species in estuarine habitats. We attempted to use this approach to better understand the expansion of Asian carp. Occurrence data from fish museums and natural resource managers covering over thirty years of sampling in the Mississippi River Basin and nearby river systems were combined into a geographic information system (GIS) database and used to create yearly distribution maps for each species. Preliminary results suggest that the known occurrence patterns for both species are the result of multiple introductions from different points. It is unlikely that expanding carp populations in the Mississippi River Basin began from a single origin. Also, as we saw with *H. cyanoguttatus* dispersion, Asian carp expansion exhibits periods of apparent stasis during which significant range extensions do not occur. Data suggest that these periods do not reflect an actual slowing of expansion but are artifacts of the limited scope of sampling efforts. While it may be incorrectly assumed that during these periods expansion is limited or has been curtailed, the invaders are likely extending their range "under the radar" of standardized sampling.

Chemical Contaminants in Invasive Bigheaded Carp of the Missouri River at Easley Missouri, 2005.

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Despite the recent introduction of invasive bigheaded carp into the Missouri River system in the 1980's and 1990's they are now extremely abundant. Efforts are underway to enhance commercial take of these species as a control measure. The primary endpoint for these commercially caught fishes is human consumption. Fish in general are well known accumulators of persistent organic chemicals, mercury and other toxic element, yet no information exists about body burdens in these invasive bigheaded carp that now inhabit the Missouri River. We conducted a study to determine concentrations of organic contaminants and toxic elements in composite samples of bighead and silver carp collected from the lower Missouri River near Easley, Missouri. Ecological and human health concerns were addressed by analyzing whole body and fillet concentrations and by determining percent lipid in various tissues to estimate contaminants in different tissues including fillet, lateral line, belly, head and organs. Results will be reported for persistent bioaccumulative organochlorinated compounds and toxic elements including As, Se, Hg, and other elements of concern. Concentrations of PCBs, chlordane residues, organochlorine pesticides, PBDE flame retardants, and dioxin-like compounds will be presented and compared to ecological and human health levels of concern.

Use of a BioAcoustic Fish Fence to Prevent the Spread of Asian Carp to the Great Lakes: Importance of Acoustic Signal Specificity

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Nonindigenous bighead carp *Hypophthalmichthys nobilis* are rapidly moving up the Illinois River towards Lake Michigan. Consequently, the use of behavioral fish guidance technology to deter the range expansion of these invaders has generated considerable interest. Experiments using a hybrid Sound Projector Array driven BioAcoustic Fish Fence (SPA driven BAFF) were conducted to evaluate the effectiveness of two different sound signals in repelling bighead carp in outdoor fish raceways. A total of 3,219 attempts to cross the SPA driven BAFF system using the first sound signal (20 - 500 Hz) were made by bighead carp. Of those attempts, 57% were successful repels. In contrast, only 284 attempts were made by bighead carp to cross the SPA driven BAFF using the second sound signal (20 - 2000 Hz) and 95% of those attempts were successful repels. Our results indicate that the SPA driven BAFF using the second sound signal can be an effective means of keeping bighead carp away from regions where their presence is unwanted.

Carpbusters.com - Carping for conservation

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Carpbusters.com is the brainchild of the Native Fish Conservancy, a non-profit conservation organization. Carpbusters promotes a simple idea. We believe that if we make permanent removal of Carp science based, fun, and good for our native fish, sportsmen will flock to it. Carpbusters networks, partners, educates, and works with State and Federal agencies and biologists to promote a good conservation model. Most of all we have fun! Our Carp tournaments have grown; in 2006 we will have some of the largest "Carp only" tournaments in the USA. Our 2006 and 2007 tournament season can be seen on Campbells outdoor challenge TV show, which will air on many cable stations, further advancing our public education efforts on the Asian carp issue.

Dietary overlap of Asian carp and native filter feeding fishes in the Upper Mississippi River System

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Bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*) were accidentally introduced into the Upper Mississippi River System (UMRS) in the 1980s, and have established reproducing populations in a large portion of this river system. Bighead and silver carp are referred to collectively as Asian carp, and are filter feeders, consuming phytoplankton and zooplankton. These nonnative fishes could exert negative impacts on three economically and ecologically important filter-feeding fishes native to the UMRS: bigmouth buffalo (*Ictiobus cyprinellus*), gizzard shad (*Dorosoma cepedianum*), and paddlefish (*Polyodon spathula*). The objectives of our study were to characterize the relationship between Asian carp abundance and zooplankton density and characterize diet overlap between Asian carp and native filter-feeding fishes in backwater lakes of the Illinois and Mississippi rivers. Our results show dietary overlap was greatest between Asian carp and gizzard shad, and there was some overlap between bighead and silver carp with bigmouth buffalo. Diet overlap was very slight between Asian carp and paddlefish. These results suggest bighead and silver carp have a greater potential to negatively affect gizzard shad, followed by bigmouth buffalo. Although rotifers made up the greatest proportion of the diet of Asian carp, there was little evidence of negative relationships between the abundance of Asian carp and rotifer density. There was some indication of negative relationships between the abundance of Asian carp and the density of crustacean zooplankton. Backwater lakes containing the greatest abundance of Asian carp had low densities of nauplii, adult copepods and cladocerans, but this relationship was only significant for cladocerans. Based on these patterns, we cannot rule out the possibility that Asian carp could reduce crustacean zooplankton density in backwater habitats of the UMRS, and could affect other zooplanktivorous fishes that consume similar taxa in this system.

A model for directed extinction of exotic fish in the wild using a Trojan fish bearing multiple Y chromosomes

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The directed extinction of an exotic fish population is proposed using a genetic approach to drastically reduce the ratio of females to males within the population. In the proposed strategy, sex-reversed female fish containing two Y chromosomes (Fyy) are introduced into a normal fish population. To produce a mathematical model of the system, the frequencies of each of the four expected genotypes of fish in the simulated population (Fxx, Fyy, Mxy, and Myy) are represented by a set of coupled ordinary differential equations. The equations take into account birth rate, death rate, and a fixed carrying capacity of the system. Using computer generated simulations, we determined that the continuous introduction of a relatively small number of Fyy females to the normal population leads to extinction of the exotic fish over time. The proposed eradication strategy is relevant to fish species utilizing an XY sex-determination system and which tolerate a YY genotype. Published literature suggests that Asian carp may fulfill these criteria and may thus be a suitable target fish for a Trojan YY fish eradication strategy. The potential of this approach for eradication of Asian carp will be considered in light of the life history traits associated with these species.

**A video for public outreach regarding silver carp and
bait bucket transfer**

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A video was produced to educate the public on silver carp using bass fishing celebrity Bill Dance as the guest speaker. The video focuses on problems associated with the silver carp including competition with native species of fish and the hazards to boaters and skiers due to their leaping ability.